Contingent Valuation of drinking water quality in Samara city*

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FINAL REPORT

Abstract

The project deals with a contingent valuation of improvements in the drinking water quality, based on the household's perception of the tap-water quality and relevant health risk avoidance behaviour. It involves analysis of the factors determining household's willingness-to-pay for improved tap-water quality, as well as individual avoidance expenditures undertaken by the households to prevent/reduce health risk from tap-water consumption. Authors compare estimates obtained by means of two different evaluation techniques: actual avoidance expenditures and hypothetical willingness-to-pay for drinking water improvement. A survey has been conducted in the big industrial Russian city of Samara.

JEL Classification: H41, Q25, Q26

Key words: *contingent valuation, willingness to pay, drinking water quality, avoidance expenditure*

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CONTENTS

INTRODUCTION

This project is an attempt to evaluate in monetary terms a subjective value of clear drinking water based on the household's *attitude* to drinking water quality and an appropriate health risk *concern*. Changes in the quality of the environment brought about by reducing the pollution of water, can lead to decreases in the incidence of disease, reduced impairment of activities, and, perhaps, increased life expectancy. The purpose of this analysis is to describe the households' *perceptions* of reduction in health risks that can be attributed to improved drinking water quality[1].

According to the economic models of an individual choice, we can interpret a household's observed trade-off between income and health as a measure of people's willingness-to-pay (WTP) for improvements in their health. Environmental pollution that impairs human health can reduce people's well-being through some extra expenditures: avoidance (mitigating, or defensive) expenditures associated with attempts to prevent pollution-induced disease; lost wages; medical expenses associated with treating pollution-induced illness, including the opportunity cost of time spent in obtaining treatment.

Reducing pollution may be beneficial to individuals because it reduces some or all of these adverse effects.

Methods of the evaluation of the benefits resulting from an improvement of the environmental quality and health can be divided into two categories: contingent valuation, based on responses to hypothetical situations posed to individuals, and revealed preferences, based on observed choices and expenditures on avoidance behaviour.

Basic task of this research is to analyse the main factors, influencing the level of the household's avoidance expenditures and the level of the household's potential willingness to pay for the drinking water quality improvement. In particular, we investigate so called preliminary information effect on the value of the household's WTP.

We also empirically test a standard economic model, explaining the link between the avoidance expenditures and the willingness to pay. The empirical part is based on the data, collected in the Russian city of Samara in April, 1999. The survey was specially designed to obtain data on the households' willingness to pay for the tap-water quality improvement

The actuality of the research is provided by the complicated and far from efficient structure of Russian drinking water supply system. Pollution of the surface and underground waters has been decreased over the last decade due to the industrial and agricultural crisis, but wear of the water treatment equipment and lack of the financial investments in the public utilities sector has been continued to contribute to the deterioration of the drinking water quality.

In the transition period of the Russian economy the water supply/treatment system has become less subsidized by the government and the main burden of the reimbursement of the water treatment costs has been laid on the industrial enterprises. Tariffs for water for households were remaining quite low. Such a disproportion together with inability of the most industrial enterprises to cover all necessary costs led to the serious drop (in spite of the industrial stagnation) in the drinking water quality.

More than 20% of drinking water in Russia does not meet sanitary and hygienic standards and about 8% does not meet the bacteriological one. About 50% (and in some regions - 70%) of the Russian population uses poor drinking water. That leads to the growth of diseases in some Russian regions (V.E. Grebcova, 1997). According to estimates of the State Institute of Medical Science and Research (by F.F. Erisman) drinking water contaminated with nitrogen and chlorine induces a significant growth of the chronic nephritis, hepatitis and still-born cases and drinking water, contaminated with bromine and boron induces diseases of indigestion and dyspepsia. This occurs in spite of the increase in availability of official information about real health risk from poor drinking water consumption becomes more open to public it is still obscure and incomplete.

The ambiguity of official information plus the increased possibilities for personal water purification have led to a quickly arising household’s drinking water quality concern and appropriate health risk avoidance behavior. Household’s expenditures, related to improvement of the tap-water quality, represent an important issue for this economic research.

The paper consists of the following sections: introduction, discussion of the methodology chosen to carry out the analysis of willingness to pay for better tap-water quality, the economic model, a description of the survey and of the data, the estimation procedure and empirical results, and the conclusion. There is also a separate appendix which contains figures, tables of the regression results, a description of variables, and the survey questionnaire which has been translated in English.

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[1] We emphasize the word perception because households never have clear, objective facts on water quality: they can taste, smell, feel and see water. They also receive various types of information on tap water quality, but it should be recognized that people take such information into account in their own way.

METHODS: REVIEW OF LITERATURE

Evaluation of the drinking water quality improvement was implemented by means of the analysis of a household's willingness-to-pay and actual expenditures on the market, related to the tap-water treatment. Such a type of the economic valuation is called non-market valuation. It is commonly used in the case when a market price of some public good (such as drinking water quality) does not represent the actual cost of the good. Basic element of the non-market valuation is the willingness to pay (WTP) of some economic agents for some change in the level of provision of a public good. Willingness to pay for being obtain this change of a public good reflects the individual's preferences, so, it can be interpreted as a monetary measure of this public good or service[2].

Non-market valuation consists of two different instruments: contingent valuation (CV) and avoidance expenditures (AE). Both are based on sociological surveys.

The avoidance expenditures approach is based on the analysis of the actual household's expenditures, related to the reducing and mitigating health risks from the environmental pollution, and it is called an indirect valuation. In AE model household's avoidance measures (for example, filtration of the tap-water) are taken as a basis for the estimation demand for the drinking water quality. If the tap-water quality declines, the households must increase their expenses to maintain constant the final drinking water quality[3].

Avoidance measures (such as a personal water treatment) can be used to evaluate an individual's WTP to reduce the health risk . When an individual can "purchase" a reduction in health risk due to the contaminated drinking water, the price of reducing that risk can be taken as a close approximation of the individuals' WTP for improved water quality. Given data for each person on the cost of avoidance measures he or she undertakes (which is likely to vary among individuals, especially if there is a time cost associated with these activities) and on the effect of avoidance behaviour on the health risk reduction, one can estimate WTP.

In the contingent valuation approach people are directly asked to estimate their willingness-to-pay for the tap-water quality improvement by using structured questionnaires. This approach is called a direct valuation. The main difference from the AE-approach is the absence of actual purchase of the good, but households' estimation of the hypothetical procedure. The questionnaire describes some hypothetical change (in the drinking

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[2] The graphical definition of the willingness to pay as a demand for clear drinking water is presented in figure 1 (Appendix).

3 Courant and Porter (1981) showed that, under certain circumstances, such an increase in 'averting expenditure' can be interpreted as a measure of welfare loss incurred by the households from the decline in environmental quality.

water quality, for example) and the respondent is asked directly for his/her *potential* WTP for this change. It is usually supplemented by attitude and demographic questions. Obtained information is used to estimate a valuation function which ‘explains’ WTP as a function of the various parameters which are theoretically expected to affect willingness to pay for clear water.

The critics of contingent valuation method are primarily critical of the reliability and validity of answers to hypothetical WTP questions. The method seems to be quite vulnerable to biases. A great deal of research has been done to define such biases and explain how to avoid them which has resulted in setting up the guidelines for conducting proper CV research (Arrow et al, 1993). One of the ways to overcome strategic bias (i.e. premeditate bias of the WTP) and information bias (i.e. arising from incompleteness of available information) may be by carefully designing the structure of the research. In particular, special attention should be paid to the questionnaire, to the selection of the sample and to the offered payment (i.e. payments in the form of taxes, monthly tariffs, etc). So called systematic biases (i.e. inherent to the CV method) can be smoothed over by the preliminary surveys in small groups

The contingent valuation issue is discussed in Mitchell, R. C. and Carson, R.T.(1989), Shibata, H. and Winrich J.S.,(1983), and in the paper of Latvian economists Malzubris, J., Senkane, S. and Ready,R (1997).

In Russia there were two relevant studies. The first was implemented in Moscow in October,1996 (Larson, B., Gnedenko, E.,1999). The second - in Novgorod region in February, 1998 (Gnedenko,E, Gorbunova, 1998). The former study has considered the possibility of applying the method of avoidance expenditures for valuation of drinking water in Russia. Statistical and econometric results related to the average and optimal level of avoidance expenditures have been obtained. The latter study has shown that, on average, a household’s WTP for drinking water quality improvement in typical small Russian town makes up to 2% of household’s income. This estimate seems to be close to the analogous estimates of the World Bank for some developing countries.

THE MODEL

Assuming individuals' preferences are characterised by substitutability between income and health, we can analyse the trade-off that people make as they choose among various combinations of health and other consumption goods, and, by that, reveal the values they place on health and healthy environment. We base our modelling on the standard economic principles and the previous research [Larson, Gnedenko(1999), Courant, Porter (1981), Harrington, Portney (1987)]. The model yields the testable hypotheses about the factors, determining the optimal level of avoidance expenditures and hypothetical willingness to pay for drinking water improvement; these hypotheses are to be tested empirically.

The household ***i*** derives the utility from the amount of market goods, X, it consumes and the level of health, H, it enjoys, in the usual way:

$U_i = U_i(X, H)$, where positive and decreasing marginal utilities implying that the two arguments of the function are goods : $U_X > 0 > U_{XX}$ and $U_H > 0 > U_{HH}$

The level of health H is obtained from the health production function :

$H = H\left(\bar{Q_c}(Q_0, A), M \middle| B_i \right)$, where ***$Q_c$*** is the household's desired level of the water quality, which is a product of the perception of the initial tap-water quality ***Q_0*** and the level of avoidance measures ***A*** undertaken by the household. ***M*** is medical expense. ***Bi*** is the vector of characteristics of the household, including income level, small children in the household, education attainment, access to the official information about the tap-water quality, and health risk concern. We assume $H_Q > 0$ and $H_A > 0$.

If the change in the water quality is a perfect substitute with avoidance activities, we can represent health production function as: $H = H(Q_0, A, M \mid B_i)$

Finally, the problem is to maximise utility under a budget constraint:

$$U_i = U_i\left(X, H\left(\bar{Q}_0, A, M \middle| B_i \right) \right), \quad s.t.\ p_a A + p_x X + p_m M <= I \qquad (1)$$

where $p_a A$ is the minimum level of avoidance activities, needed to obtain desired level of the water quality given the household's perception of the initial quality Q_0. p_X and p_A are, respectively, the price of the market goods and of the avoidance activities, I is total income , and p_m is a price of the medical services.

Using the Roy's identity, the household's optimal choice of avoidance can be written as: $A_I^* = -(\partial U_I/\partial p_a)/(\partial U_i/\partial I)$, which is the optimal expenditure-minimizing level of the avoidance activities. Simple comparative statics allows us to test the following assumptions about the effect of the tap-water quality and cost of defensive activities on the household's optimal choice of avoidance:

$\partial a^*/\partial p_a <= 0$, $\partial A/\partial Q_0 > = < 0$ [4], $\partial a^*/\partial I >= 0$ *if it is a normal good* (2)

Further, households' health risk concern, which is obviously related to the drinking water quality, is expected to have the same effect on the level of avoidance as the water quality. Since it is not clear from the theoretical model, which sign is true, this relationship is to be tested empirically. Intuitively, one can expect a reciprocal relation: the worse the tap-water quality, the more the health risk concern, and, consequently, the more avoidance activities are undertaken by the household.

The effect of socio-demographic characteristics (education level of the household, small children, etc.) and access to the official information about the tap-water quality is an empirical question also.

Hypotheses about the factors affecting the hypothetical WTPs may be derived from the indirect utility function from the maximization problem in (1):

$\partial WTP/\partial A^* <= 0$, $\partial WTP/\partial Q_0 = <0$, $\partial WTP/\partial I >= 0$, $\partial WTP/\partial B >=< 0$ ***(3)***

It follows from the definition of the WTP as a maximum amount of income that a household is willing to pay after the quality change to remain as well off as before the quality change. An answer about the WTP for clear drinking water can be represented as the difference between the expenditure functions:

$WTP = E(Px, Pm, Pa, Uo, Qo, B) - E(Px, Pm, Pa, Uo, Qc, B)$ ***(4)***

The value of the first function is I_0, the household's current income; the value of the second expenditure function is the level of income I, that solves for U_0 given prices, water quality and household's characteristics. WTP is defined as the difference between I and I_0. Thus, willingness to pay, technically called equivalent variation, can be written as a function of several exogeneous variables, namely: the total household's income *I*; the initial and the final water quality Q_o, Q_c [5], prices of avoidance activities and other goods, and some characteristics of respondents and their families, such as: age, sex, education level, income, small children. If evaluation of the drinking water quality obtained from one group of people are to be transferred to other groups, it is essential that we know how WTP varies with these individual characteristics. Because data on socio-economic variables can be easily gathered along with contingent valuation responses, it is possible to describe WTP as a function of all these variables.

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4 Relation between the level of avoidance and the initial water quality is ambiguous: ∂A/∂Q0 can be either positive or negative. For details see Larson, Gnedenko, 1999.

5 Final water quality can be approximated (in the context of the data available) by the variable of health risk concern, which is an empirical proxy for $H(Q_0, A)$ in our model.

Since WTPs, obtained in the survey, are contingent on the availability of information about health risk from poor drinking water, special accent is to be done on the information effect on the WTP. In order to analyse the individual preferences for risk reduction, the respondent must be informed about the health risk being valued. The more information provided to the household before the survey, the bigger the WTP are usually obtained. This assumption, known as a preliminary information effect, is to be tested empirically.

Finally, the empirical comparison of the obtained AE and CV estimates of the WTP allows us to check two competitive theoretical conclusions.

BRIDGE TO EMPIRICAL ANALYSIS OF THE AE AND CV ESTIMATES

The important question that we consider in the empirical part is the difference between contingent valuation and the avoidance expenditures estimates of the willingness to pay for the clear tap-water. The analysis of the estimates is based on two theoretical approaches developed in Dickie et al (1986,87) and Harrington and Portney (1987).

The studies of Dickie, which were conducted using the same respondents, permit comparisons between the two estimates. The two methods produced the estimates that were about one order of magnitude apart[6]. The avoidance expenditures estimate of WTP was regarded as an upper bound because the full cost of avoidance activities that produce joint products were attributed to reducing pollution exposure. It suggests that household's avoidance expenditures on average should be higher than it's willingness-to-pay for clear water.

However, as shown by W. Harrington and P. Portney, the WTP for tap-water improvement can be written more explicitly as a combination of two terms: the dollar value of the utility improvement due to decrease of poor water quality-induced illness; plus the reduction in avoidance expenditures associated with an improvement in the tap-water quality. Following Harrington and Portney, the marginal WTP can be written as:

$$\frac{dI}{dQ} = -P_a \frac{\partial A^*}{\partial Q} + \frac{U_h}{\mu} \frac{\partial H}{\partial Q} \tag{5}$$

From (5), if the water quality improves[Q_0 increases], expenditures on avoidance measures fall ($Pa\ (\partial A^* / \partial Q) < 0$) . At the same time, the increase in Q_0 means that the household health improves from the health production function ($\partial H/\partial Q$), where the term U_h/μ is the household's shadow price of health. Thus the change in the avoidance expenditures for a water quality improvement <u>underestimates</u> the household's total WTP for this improvement Equation (5) suggests that household's avoidance expenditures on average should be lower than it's willingness-to-pay. The same theoretical result has been obtained in Larson, Gnedenko (1999).

The empirical test of these theoretical results, using data of the survey in Samara-city, is described in the following sections.

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[6] The problem may arise when the avoidance activity produces joint products (as if someone boils water not only to kill germs but also to make tea). To avoid this problem, usually interviewers make special accent on the purpose of the questions, and the value of joint products is assumed to be zero.

DATA

The sample

The main source of data for this research was the sociological survey implemented by the author in Samara in April 1999 with financial support of the EERC (Economic and Educational Research Consortium). Samara is a typical large Russian industrial city. It's water supply is based on the river Volga, which is notoriously contaminated with chemical and biological substances (Dronin, Motovilova, Magin, 1997). There is an evidence of the continuous deterioration of the tap-water quality in Samara-city and increase of the morbidity rate due to poor drinking water quality in the city (Data of the Samara Committee for Sanitary and Hygienic Supervision (1999)).

The population of Samara city is 1,179,200 people, or 336,173 households (data of Upravleniekommunhoz, 1997). Samara consists of 9 districts. Districts differ from each other by the proportion of households, connected to the municipal water-treatment system and by the condition of their water-distribution networks.

To make a statistically representative sample of the population of Samara and to provide further informative analysis, data has been gathered from the following organizations: the Samara Health Department, the municipal water department "SamaraVodokanal", the public utilities enterprise "Upravleniekommunhoz", the Samara Sanitary and Epidemiological Supervision Committee, and the State Statistical Committee of the Russian Federation.

Data about the source of drinking water for households (wells, tap-water, etc.) were used for a proper sample design. The respondents provided with the tap-water in the house only were the objects for the research. These respondents, in turn, were divided into two categories, according to the type of the tap-water in the house: the first group, supplied with the drinking water from the municipal water supply system and the second group, provided with the tap-water from the oil-refining (!) plant.

To avoid general systematic biases inherent to contingent valuation studies, the pilot survey has been carried out on a small group of 35 respondents. Then, taking into account information obtained in the pilot survey, the basic poll has been conducted. It was done by the author and a group of professional interviewers from the Regional sociological research center, Povolzhsky Branch of Russian Sociologists Association.

The total sample size equals 749 respondents. The econometric analysis have been conducted on the reduced sample of 694 respondents, that included only households having the tap-water in their houses.

The Questionnaire

The Questionnaire used in the survey includes five sections: 1) source of drinking water for the household; 2) opinions about the tap-water supply and quality; 3) willingness to pay for different types of improvement of the tap-water quality; 4) household's avoidance behaviour; 5) socio-demographic characteristics of respondents and households.

In the first section respondents are asked about the water source in their household and type of the building they live in. In the second section the attitude towards the tap-water quality and relevant health risk is investigated and respondents are required to provide information about their dissatisfaction of the tap-water (aesthetic inconveniences, rusty deposits on the sinks, negative health effect, etc.). The third section of the Questionnaire includes open-ended questions about the household's WTP: All these questions were used to get the most precise data for econometric analysis of WTP. We decided do not include close-ended WTP-questions such as "Would you agree to pay N rubles per person monthly for the tap-water quality improvement in your town?" because such question form could prevent the respondents formulate their own estimates of the offered tap-water quality improvement. Instead, several WTP-questions were presented in the open-ended form:

1. "How much would your household be agree to pay monthly for provision of the additional tap-water treatment?" This question allowed a respondent to formulate the estimate on the basis of his/her own understanding of the problem.

2. Three different programs of water quality improvement have been offered to respondents to evaluate their WTP for each of the programs. "How much would you agree to pay for the following tap-water quality improvement programs: at the house level, district level and city level?" This question allowed to show respondent's preferences among different types of water cleaning. It shown that the value of household's WTP depends on the amount of the tap-water quality improvement. This result has become a basis for analysis of WTP for each program of water purification in Samara.

3. "What form of payment (taxes, additional monthly utility payment) would you prefer?" This question supposed to make hypothetical payment for some tap-water improvement more realistic.

Section 4 of the Questionnaire contains questions about avoidance behaviour of households (boiling, settling, filtering, substitution of the tap-water by the bottled water), and corresponding expenditures. Section 5 concludes the Questionnaire with questions about socio-demographic characteristics such as age, occupation, sex of the respondents, average household's income, educational level, are there any small children in the household, etc.

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BASIC STATISTICAL RESULTS OF THE SURVEY

Drinking water quality

The statistical results of the survey have shown actuality of drinking water quality problem for Samara households. Households that were not satisfied with the tap-water quality represent half of the total sample. The most popular reasons for dissatisfaction are the following:

- bad taste - 35 %
- bad smell – 22%
- residual sediments in the water – 20%
- scum on the dishes - 20%
- coating of the sink surface – 50%
- deterioration of water distribution tubes – 33% of the sample.

Situation is not the same throughout the different city districts: households living in Kuibyshevsky and Krasnoglinsky districts (further let's call them 'industrial' districts) are more dissatisfied with the tap-water quality: their households are supplied with the purified water from oil-refining plants, not from municipal water treatment facilities.

Household's average monthly losses due to poor tap-water quality amounts to 75 rubles ($3). It equals 4.5% of the average *household's* monthly income (April, 1999, Samara). This figure varies through the districts, and reaches maximum in two 'industrial' districts. In these districts tap-water is so bad, from the respondents words, that domestic appliances (such as washing machines) breaks down permanently.

Just 6% of the sample answered they have enough information about tap-water quality. It was not enough to carry out statistically significant analysis. However, this result was expected for the Russian city, and the total sample was divided into two nearly equal, properly stratified subgroups. Some information about actual water quality in Samara and health risk associated with poor drinking water quality has been provided only to the first subgroup before the respondents answered the WTP-questions. It has been done in order to investigate the information effect on the household's WTP [the more preliminary information, provided to the households before the survey, the higher their WTP]. To make each subsample representative both were stratified by the parameter of the household's average income in accordance with the total sample proportion. The statistical chi-squared test confirmed the lack of correlation between income and preliminary information (tables 1, Appendix). Thus the difference in WTP in different subgroups could not be caused by the different welfare of households, but can be explained by different levels of provided information of the tap-water quality. The estimated mean WTP value with initial information equals to 12.92 and without initial information is 12.42 rubles per person per month. Tests confirmed statistical difference between WTP values with "initial information" and without it

Avoidance behaviour

More than three quarters (!) of the households believe that the problem of poor drinking water quality is a serious problem for health. 94% consider negative health effect as the most important consequence of the poor tap-water quality. Such situation induces widespread health risk avoidance measures. 71% households undertake avoidance measures to make their tap-water acceptable for drinking and cooking purposes. About 30% households regularly settle tap-water before consumption or cooking, 67% - boil, 12.7% -filter and 9.4% - regularly use bottle water as a substitute of the tap-water.

Majority of respondents confirmed that their choice of avoidance measures is based on two factors: degree of health risk reduction and the cost of avoidance measures. The proportion of households undertaken cheap avoidance measures (settle the tap-water, boiling water) is less than those used expensive measures (filters, substitution of the tap-water with the bottle one). The mean level of avoidance expenditures is 40-60 rubles per month (per person).

WTP for water quality improvement

The overwhelming majority of the households confirmed that would decrease their avoidance expenditures if additional water treatment projects were implemented in the city.

77% households believe that implementation of some municipal drinking water quality improving programs is necessary and timely. The majority of the households agree to financially support such actions (i.e. their WTP more than zero). About 80% of them prefer payments for water quality improvement as an addition to the monthly utilities fee.

Among those households who favour water treatment programs, the average willingness to pay for their implementation equals 12 rubles (about 0.5$) per person per month (table 1).

Table 1. Descriptive Statistics of the household's WTP (rubles per person monthly).

	N	Minimum	Maximum	Mean	Median
Maximum WTP	694	0	300	12	5

Median WTP equals 5 rubles (20 cents) per person per month. Difference between mean and median can be explained by that the former is affected by a relatively small number of high WTP-values and therefore takes higher value. Using regression framework, we weighted the "right side" outliers down for further statistically justifiable econometric analysis. The public choice literature places more emphasis on a "voting criteria" in making decisions about public goods and prefers median estimates of WTP. The program that is justified using the mean WTP may not be adopted using usually lower value of median WTP estimate.

However, the standard economic welfare, benefit-cost framework (Just, Hueth, Schmitz, 1982) favours the mean WTP. One of the most convenient ways to display the difference between these two measures is to graph the probability density distribution of WTPs (figure 2, Appendix).

This procedure allows to extrapolate individual estimates of WTP, obtained in the survey, for the whole city and to predict the probability of the aggregate households' support of the drinking water quality improvement in Samara. The curve shows probability of households' support tap-water improvement projects at certain prices.

The WTPs from our 1999-survey in Samara are quite comparable with the 1998 figures, obtained in the analogous CV research in small Russian town in Novgorod region (Gnedenko, Gorbunova) in 1998: the median WTPs were 6 and 5 rubles per person per month respectively. However, purchasing power of 5 rubles in April'99 does not equal to that in February'1998. 6 rubles ($1) in 1998 were about 2% of households' average income, while the 5 rubles (20 cents) in 1999 were about 0.5% of the average income.

Non-willingness to pay for water quality improvement

159 respondents (23% of the sample) refused to support offered public measures. While for ordinary surveys the item non-response rates do not usually exceed 5-7 % (with exception of questions for the respondent's income), non-response levels in CV surveys of 20 to 30% for the WTP elicitation questions are not uncommon (Craig and McCann 1978). Up to a certain point these higher levels of non-response are acceptable and even desirable in the sense that it is unrealistic to expect that 95% of a sample will be willing to expend the effort necessary to seriously consider WTP amount for a special type of environmental public good. A respondent's refusal is often associated with a lack of interest in the topic of the survey (Stephens and Hall 1983). Therefore, it seems reasonable to assume that people who are less interested in the good will value it

differently than will their more interested counterparts. Also, response rates typically vary across population groups, such as lower and higher income groups.

To determine whether observed non-response results in bias for a given study, we addressed two questions: one is whether there are differential response rates across some groups of households (different income levels, different educational levels), and the second is whether there are systematic differences between those within a particular group who responded and who did not. Sample non-response bias occurs when these between- and within-group differences in response rates exist and related to the value of the good. That is, if the sample distribution of predicting variables for WTP-function differs significantly from their joint population distribution. Among those households who do not undertake any avoidance measures and don't want to support water projects are mainly the families with low income. This empirical result is consistent with our theoretical model assumed higher income to be an important factor influencing the WTP. Thus we decided do not discard observations with zero WTP-responses (that would be wrong from statistical as well as from economic points of view) and used them explicitly in the econometric analysis.

After checking and "cleaning" our sample, we classified main reasons for 23% households having zero WTP for offered public water improvements as following :

- mistrust towards the local authorities (they will not spend money properly) (30%);
- budget constraint of the household (24%)
- satisfaction/reconciliation with current situation (23%)
- preference for personal avoidance measures (17%)

WTP for the different types of the tap-water quality improvements

Survey results shown that average WTP varies over different types (projects) of the offered tap-water quality improvement. Brief description of the projects is available in the questionnaire (Appendix). The WTP for different projects are presented in the table 2:

Table 2. Difference between WTP (rubles per person monthly) for three types of the tap-water quality improvement.

	N	Minimum	Maximum	Median
WTP - house	694	0	300	5
WTP - district	694	0	100	3
WTP - city	694	0	100	2

Median WTP for water quality improvement in the house exceeds the WTP for water quality improvement in the district, and median WTP for the tap-water improvement on a district level exceeds median WTP for the tap-water improvement in the whole city. Actually the level of water quality treatment in each program reflects the amount of the quality improvement: the water quality change is assumed to be higher at the house level and the lower at the city level. These results reflect, in some extent, the fact that the larger the tap-water quality change (improvement) is offered the more the willingness-to-pay for it. Respondents believed that water improvement at the house level will result in the better final tap-water quality than other two programs (partly because of better control over house-level program, etc).

In order to test the robust difference between WTP among different programs the non-parametric Friedman test has been used. Results are presented in table 3 (Appendix). The assumption of robust statistical difference between various levels of WTP-values has been confirmed and shown evidence that the change in water quality is an important factor, determining WTP. Since the precise measurement of such a change is impossible in CV study, further econometric analysis of the factors affecting WTP has been conducting separately for each level of the water improvement.

ECONOMETRIC ANALYSIS

Contingent valuation approach

In order to test the relation between WTP and socio-economic factors in (4), the econometric analysis has been done. In the regression model WTP for clear drinking water was represented as a dependent variable:

$WTP_i(Q)=\beta_0 + I_i\beta_1 + Q_0\beta_2 + A_i\beta_3 + B_{i1}\beta_4 + B_{i2}\beta_5 + B_{i3}\beta_6 + B_{i4}\beta_7 + B_{i5}\beta_8 + B_{i6}\beta_9 + \varepsilon$,

Where I is an average family income, Q_0 is the household's perception of the tap-water quality (in the regression there were two variables, related to this parameter – source of the tap-water (oil-refining plant or municipal water-supply facilities) and household's opinion of the tap-water quality; A_i – avoidance behaviour undertaken by the household (yes/no); B_{ii} denotes the socio-demographic characteristics of the household: B_{i1} – education attainment; B_{i2} – small children in the household; B_{i3} - information , provided to the household during the survey (this dummy-intercept parameter was used together with dummy-slope parameter - interaction term 'information*risk', that indicates that additional information about the risk from poor drinking water quality may change the perception of health risk as well as willingness to pay); B_{i4} –age of the respondent; B_{i5} - sex of the respondent, B_{i6} - marital status of the respondent, B_{i7} – health risk concern.

In our empirical model we are not considering medical expenditures explicitly[7], taking into account only households' expenditures on avoidance measures as a factor determining the WTP. The expenditures on medications, related to illness, induced by drinking water pollution, are also considered as a part of avoidance expenditures, assuming that medications can be viewed as a pure avoidance good with a cost that is easily measurable. Since the price of avoidance measures and of all other goods do not vary across people in the city they were not included in econometric model.

Questions were asked in the ordered-categorical form and then were transformed into binary variables. The exogeneous variables were defined as dummy (1/0). All variables are based on the survey data. The variables, used in the analysis, are described in the table 2 in Appendix .

Note, the variable of the initial tap-water quality reflects respondents' perception rather than actual chemical characteristics of the tap-water. Furthermore, objective levels of risks are assumed to correspond to individuals' risk **perceptions** at the time their market decisions were made. We estimated WTP based on

7 Visits to doctor, are assumed "fee free", since in Russia cost of medical treatment has been low during decades of Soviet era. Now the situation is changing, prices of medicaments are rising and private clinics are opening. However, for majority of population in Russia it is typical to spend nothing for visits to doctor and for hospitalisation. Long queues induce people to try to avoid visits to doctors unless there is a survival necessity.

people's perceptions of risk instead of using the actual levels of health risk from drinking water consumption in city of Samara. There is no consensus on how best treat the issue of risk associated with environmental commodities. Most indirect market studies use objective measures of risk rather than measures of individuals' perceptions of risk. Information about how closely the two correlate, however, is scant. In avoidance behaviour studies it is assumed that individuals' perceptions of the change in risk caused by avoidance activity equal the objective risk change. (Cropper M., Freeman 1991). Evidence on the accuracy of risk perceptions is provided by studies Slovic, Fischhoff, Lichtenstein (1979), Hamermesh (1985). They found, that, on average, people overestimate the likelihood of infrequent causes of health risks but underestimate the probability of getting serious chronic diseases with higher frequencies (stomach cancer, kidney disease, and other illness, that might be related to the poor drinking water quality).

What matters is an accuracy in measuring people's perceptions of the differences in risks between initial state (quality of public good) and final state (resulting from avoidance behaviour of households or the implementation certain public environmental program), and not the absolute level of these risks. Some evidence makes clear the validity of research based on the subjective risk estimates. It must be assumed, of course, that the individual correctly perceive how effective his avoidance behaviour actually was. Among published studies of avoidance behaviour that have used the data on risk perceptions is Ippolito and Ippolito's (1984).

The variables *risk* and *disease* reflect the attitude of households to health effect from tap-water consumption. Due to multicollinearity between these two variables only the variable *risk* was included in the model. The socio-demographic variables are age of the respondent, education attainment of the most educated family member and sex of the respondent (parameter *marital status* was as well excluded due to the multicollinearity effect).

Taking into account that WTP is not allowed to be negative it was decided to use Tobit regression framework for the analysis of the basic factors affecting household's willingness-to-pay. The quantity of water improvement was determined by the questions in the survey – people were asked to evaluate their WTP for a particular water treatment program. The main results of Tobit regressions for each program are presented in table 4 (Appendix).

Probability of the regressions equals 0.00, that is a good indicator for these models. Information, obtained from the analysis of households' WTP has shown that willingness to pay for water improvement in Samara is mostly influenced by the following factors:

- income
- water quality perceptions
- avoidance behaviour
- age
- sex

For the given significance level analysis has confirmed the theoretical assumption of influence of the households' income on the WTP: both income variables (high and low) are statistically significant at the 0.01 level in regressions for all three types of the water purification programs. The coefficients are positive and take bigger values for the higher levels of income. The fact that the coefficient for income HIGH is greater than that for income MEDIUM is consistent with our theoretical hypothesis: the more the household's income, the more the household's willingness to pay for the tap-water purification. This result also coincides with other WTP studies (Gerking et al, 1988, Jones-Lee, et al, 1985) and with standard economic principles.

As also was appeared at the 10 per cent significance level, WTP is reciprocally affected by the tap-water quality. The worse the initial quality the more households are willing to pay for it's improvement. This empirical result confirmed the theoretical assumption (6) about initial tap-water quality effect on the household's WTP for it's improvement. The coefficients for variables *source, quality* are statistically different from zero for two types of water improvement and have a negative sign. In words, the worse the opinion of the household about the tap-water quality, the more it's WTP for it's improvement, and the households, supplied with the tap-water from oil-refining plants, have less WTP for water improvement – they simply prefer to switch to the municipal water-supply system. Both coefficients in the third model for WTP at the house level are not statistically significant at the accepted significance level (10%). Thus, the sign of relation between initial tap-water quality and WTP for the house level water quality improvement is not clear from the empirical analysis. This result can be explained by Slutsky theorem – the sign can be both positive and negative depending on which effect – negative substitution or positive final quality effect - has bigger value (Larson, Gnedenko, 1999). Intuitively, it is likely to be explained by the fact that when the tap-water quality is bad, than households prefer to pay for public programs of water improvement for the whole city or district; at the household level they are undertaking their own avoidance measures , so that WTP for this type of water improvement does not depend on the water quality .

Undertaking of the avoidance behaviour by the household does affect the declared WTP values in the survey. The coefficient of this parameter shown significance in all three models. Coefficients are negative, which indicates that relation is reciprocal, as it would be predicted by the theory.

The availability of preliminary information about water quality did not show significance but the interaction term did. It implies that information does have its effect on the value of WTP, but it is indirect effect through the change perception of the household about water quality and correspondent health risk. Effect is positive.

Parameter of health risk concern (*risk*) is not statistically different from zero, at the 0.05 significance level in all three models. It might be explained by that respondents in their answers considered as the most important consequence of the poor tap-water quality it's negative influence on human health. Although the multicollinearity effect (the vector of the variable *risk* might be highly correlated with the vector of the variable *quality* by the close nature of these questions) has not being revealed.

In all cases *age* of the respondents has shown it's influence on the WTP answers: coefficients in all three models are negative - the younger the person the more his/her willingness-to-pay for clean drinking water. From a policy perspective it is important to know how WTP varies with current age. Life-cycle consumption models (Arthur 1981; Shepard and Zeckhauser 1982, 1984) , in which consumption is constrained by income early in life, suggest that WTP for a change in current risk to health should increase with age 40 to 45, and decline thereafter.

However, if there are small children in the household, the health risk concern tends to increase. Parents can be expected to gain utility from the health and well-being of their children; their WTP to avoid adverse health effects in their children can be taken as the appropriate measurement of benefits from risk level reduction. However, the functional form of measuring "*small children*" contribution in the overall WTP values is not simple. Thus, in spite of the parameter of small children in the household (*children*) has not shown it's effect on the WTP-values in our models. It might be some other functional form, which will allow us to reveal presence of this effect on the WTP.

The variable 'university education' (*educhigh*) has not significantly different from zero coefficient. The higher the educational attainment in the household the higher the WTP for additional drinking water treatment. This result can be explained by specific structure of the data available – question asked the attainment of the most educated family member, , which could not be reflected by the answer of other member (if the respondent was not the most educated person in her/his household).

The variable *sex* of the respondent are not proved to be strong factors affecting household's WTP at the district and city levels. However, at the house-level water improvement program the coefficient is significant at 0.10 significance level and has negative sign: that is, female respondents have demonstrated less WTP for the in-house water improvements than male respondents. This can be explained by the fact that women spend more time at home and could prefer to undertake their own avoidance measures.

It doesn't necessarily mean that this factor doesn't influence the WTP. This effect on the WTP for city- and district-level programs, if there is any, is not significant enough to be confirmed by chosen econometric model.

Avoidance expenditures approach

From theoretical hypotheses of equations (3) we estimated the following regression equation:

$$AEi(Q) = \beta_0 + Ii\,\beta_1 + Q_0\,\beta_2 + Bi_1\,\beta_3 + Bi_2\,\beta_4 + Bi_3\,\beta_5 + B_{i4}\,\beta_6 + Bi_5\,\beta_7 + Bi_6\,\beta_8 + \varepsilon \qquad (9)$$

The survey asked questions about avoidance expenditures in an ordered categorical form (see table 5a in Appendix with the survey results). Given choices for the five possible categories of expenditures, the regression model to be used is the ordered probit. We model the probability that given respondent spends specific amount on avoidance activities, dependent on the set of exogeneous variables from the theoretical model (income of the household, water quality, that is reflected by several variables: opinions of the water quality and health risk, source of the tap-water for each household, amount of information available to the respondent before survey, and the set of socio-economic characteristics of each household (age, marital status[8], age, education attainment, small children, sex). The exogeneous variables are defined in the same way as in the regression models for the WTP. There are only two exceptions: for the parameter *information available.* CV-model used as a proxy variable information, provided to the households in sub-samples immediately before survey, and in the AE-model, since avoidance activities were undertaken before respondents were divided into two sub-samples during the survey, other variable has been used - permanent access of the household to the official information about water quality. This difference between the two models implies also exclusion of the interaction term (water quality opinion *information) out of the AE-model. Results of regression analysis for the model with the maximum likelihood value are shown in the table 4 (Appendix).

The income parameters (*high and medium*) are statistically significant at the 1 per cent significance level; the parameter *high income* has a positive sign and the parameter for *income lower* has a positive sign as well. The coefficient is bigger in case of higher income variable. That is, the probability that household undertakes avoidance expenditures increases for higher income households, and decreasing for low-income households. This result is exactly as would be expected in economic theory.

From the regression, we estimated probability of a particular income-group household to undertake certain level of avoidance activities. For example, the probability for a high-income household to chose the high level of avoidance expenditures is 53%, while it is for the low-income household is only 7%.(table 6, Appendix)

Effect of the tap-water quality has been confirmed at the 1% level of significance. The parameter of the water quality is negative, that implies people systematically undertake more avoidance activities as water quality declines. Positive coefficient for the variable source shows that households, supplied with water from the oil-refining factory, spend more on the in-house water treatment than the households, connected to the municipal water-supply system.

The information effect was not demonstrated by the probit model. The better the household informed about health risk from poor drinking water consumption the higher it's expected avoidance expenditures for the water quality improvement. However, if there is a situation, when household receives the obscure information from different sources (neighbours, TV ads of the water filters, etc) or information is available to only small group of population (6% in our sample!), then information effect may be hardly identifiable or there is not enough data to show effect of the information parameter on the choice of avoidance level.

Sex of the respondent has shown its effect at the 5% level. - the coefficient is negative, which might mean women try to avoid expensive avoidance measures, preferring cheap measures, such as settle tap-water before use, boiling, using spring water source if there is any not too far from the household.

Other parameters, such as marital status, age, risk, educational attainment, small children in the household, are not statistically significant in the chosen probit model. However, one may not exclude from consideration such factors since they may affect the households' behaviour reflected by some other functional form.

Comparison of two estimates of WTP

Comparing the empirical average estimates of monthly avoidance expenditures and answers to WTP questions, we concluded that the AE-estimate is systematically higher than CV-estimate of WTP. The mean AE-WTP equals 50 rubles per month per person, while the mean CV-WTP is 12 rubles per month per person (table

[8] As in case with WTP model , the variable "status" was excluded from the analysis due to it's multicollinearity

5b, Appendix). It goes against the theoretical result obtained by Larson, Gnedenko (1999) and Harrington, Portney (1987).

However, it coincides with another theoretical conclusion – made by According to our and Dickie's results, the avoidance expenditures estimate of the WTP represents an upper bound of true value . Some households' preference for personal avoidance measures, shown by our survey, might explain the difference between two estimates of WTP. As it was statistically shown by the tobit analysis of the direct answers about the households' WTP for drinking water improvement, WTP of the households, undertaken avoidance measures, was less than that of the households, which didn't undertake any avoidance behaviour. Since the majority of the population (71.3% of the sampled households) are undertaking avoidance measures, which, in turn, decrease the probability of high willingness to pay for any additional public water improvement, one can expect that on average the hypothetical WTP estimate should be lower than the indirect one (AE estimate). Mistrust towards the local authorities, demonstrated by some households during the survey, also lowers the willingness of households to pay .

with other socio-demographic parameters.

SUMMARY AND CONCLUSIONS

In the framework of the economic model willingness to pay for a marginal change in the drinking water pollution represents the rate of substitution between pollution and avoidance expenditures,

$$WTP = - (\partial H/\partial Q_0)\, p_a \,/\, (\partial H/\partial A) = P_x\, U_H\, (\partial H/\partial Q_0) \,/\, U_x \qquad (*)$$

As (*) shows, the WTP for a marginal change in pollution of the tap-water equals the resulting reduction in sick time, $\partial H/\partial Q_0$, times the value of this reduction, $p_a / (\partial H/\partial A)$. Thus, expenditures on avoidance activities, such as purchasing bottle water or using water filters, can be used indirectly to estimate WTP for a particular water improvement. Also, the estimate of the true WTP may be obtained by direct survey of people's WTPs for the drinking water quality improvement.

Econometric analysis of the factors, affecting WTP, is proved to show some empirical evidence of the theoretical assumptions. Curve of the probability density of the WTP-values was constructed and may be useful for analysis of the water quality demand in Samara.

We made an attempt to compare the empirical estimates of WTP obtained by two different methods: CV and AE. The advantage of the indirect approach (AE) is that it is based on the observed behaviour; however, avoidance activity may produce joint products. The direct method (CV) avoids the above problem by asking each person to value a particular change in the environmental quality, which reduces health risk. The disadvantage here is that evaluation is based on the answers to hypothetical questions. Answers to hypothetical questions may be unreliable because individuals may not have been encouraged to think about opportunities for avoidance behaviour they already undertaking, or, the reverse, individuals are not incurring actual expenses, and, therefore, they may not carefully consider their budgets in answering questions.

Econometric analysis of the survey data determined the main factors influencing avoidance expenditures and hypothetical WTP, given the significance level and chosen linear functional form for the models. For avoidance choice these factors are income level, education attainment and possibility to undertake the avoidance activities. For the CV estimate of the WTP main factors are: tap-water quality opinion and health risk concern, tap-water source for a particular household, income level, available information about water quality and associated health risk., age of the respondent, and, for house-level of the water improvement projects – sex.

The result of the comparison of the two WTP-estimates has not confirmed the theoretical model in (7): the estimated WTP by AE-approach was not lower than that of CV-approach. Probably, this result might be explained by the fact, that personal water treatment in Russian cities is more preferable by the households than willingness to pay for additional water improvement , undertaken by the municipal authorities. It is possible also, that AE-estimate of the true households' WTP included the additional "multipurpose" effect (effect of joint products) of avoidance activities, which was considered by Dickie, et al (1987), although the survey design, used in our analysis, should have been avoid of such kind effect.

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